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The exceptional 29 October 2018 event over Italy: analysis of GPM measurements and products and link to precipitation formation processes

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1. Introduction

The Mediterranean region is a unique meteorological environment and a weather forecasting challenge. Over this area severe weather events of different nature often originate and develop over the sea hitting coastal regions and causing major damages and casualties.

Between 27 and 29 October 2018 a typical autumn synoptic pattern over the western Mediterranean (deep, slow-moving trough) was responsible for ***one of the most severe weather events over Italy in the last century***. An extremely intense Saharan dust outbreak over the Mediterranean was also associated to this event.

GPM constellation radiometers are used to carry out an observational analysis to characterize the dynamical and microphysical features of the storm, and to monitor the evolution of the precipitation. Similarly, ground-based and space-based aerosol and cloud measurements are combined to explore evidence of possible indirect effects of desert dust aerosol on cloud microphysics. WRF-Chem model is used to explore key mechanisms leading to the formation and evolution of the investigated meteorological system. In particular, we investigate the possible role of the intense Saharan dust transport in the development phase of the storm.

This study represents a test bed to explore the potential of combining multisensor/multiplatform satellite data and products to effectively characterize and monitor severe weather events, and ultimately to improve forecasting capabilities, in the complex Mediterranean region.

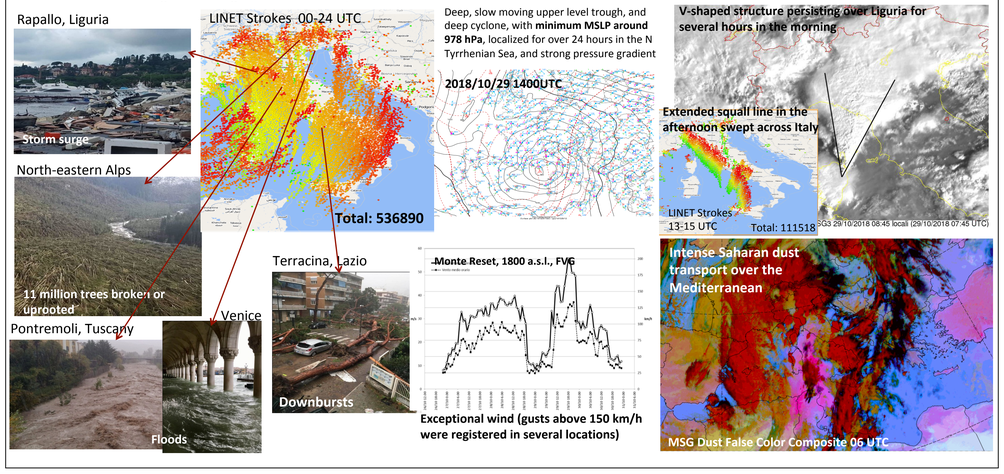
2. Goals

Multisensor, multiplatform observational analysis of 29 October 2018 extreme event over Italy is carried out to:

1. Investigate to what extent spaceborne MW radiometers can be exploited to characterize and monitor the evolution of such complex system throughout its different phases
   - **-> GPM constellation radiometers + LINET network;**
2. Assess state-of-the-art satellite precipitation product quality and evidence their strengths and weaknesses for different precipitation structures and regimes
   - **-> GPM-era precipitation products (H SAF and NASA) + raingauges;**
3. Understand the role of the intense Saharan dust transport in the development phase of the event, and how that ultimately affects precipitation, through:
   a. Observational analysis of upper level clouds microphysical properties and their relation with the intense Saharan dust outbreak during the event;
      - **-> MSG, MODIS, VIIRS, Sentinel 5 (AOD and Upper cloud properties);**
   b. WRF-CHEM model simulations of desert dust aerosol effects on cloud microphysics (in progress)

3. Italy 29 October 2018 event highlights

The Northeastern Italian Alps were particularly affected by heavy precipitation, but also Central Italy and the Liguria region registered several hundreds of mm of rainfall (up to 250 mm in 24 hours, and up to 600 mm in 72 hours were registered in several locations). In terms of dynamics, the event was very lively and interesting, characterized by low level jet, moisture transport, explosive cyclogenesis, storm surge, and culminated with an exceptional wind storm over the Alps. Floods and severe damages were registered across Italy.

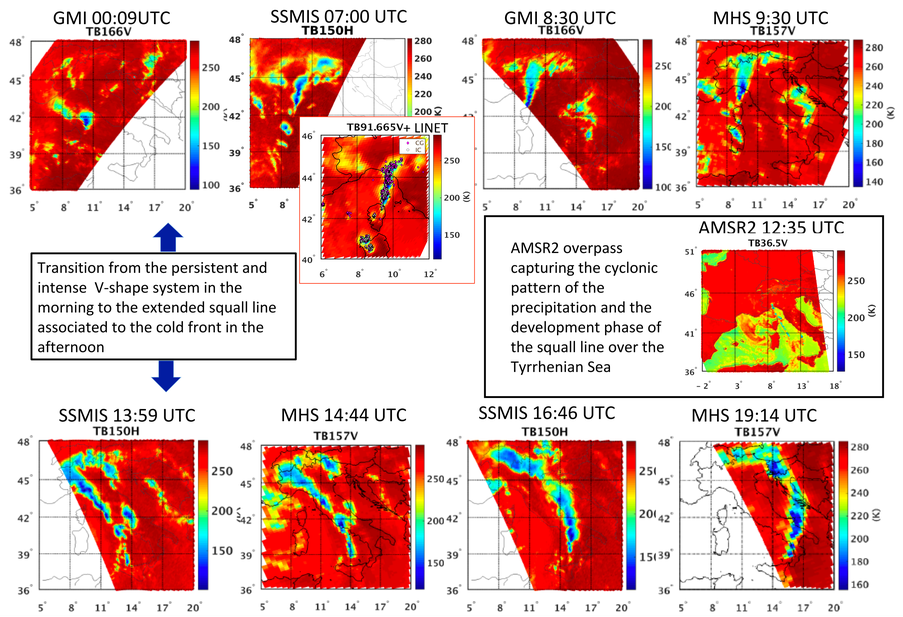


List of GPM constellation MW Radiometer overpasses for 29 October 2018 event

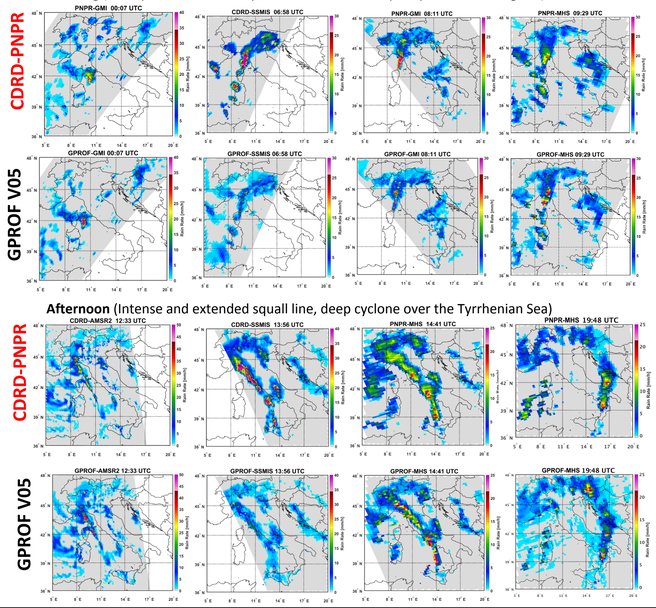
Time (UTC)	GMI	SSMIS	AMSR2	MHS	ATMS	All
00:00/01:00	X					X
01:00/02:00			X			X
02:00/03:00						
03:00/04:00		X				X
04:00/05:00		XX				XX
05:00/06:00		X				X
06:00/07:00		X				X
07:00/08:00				X		X
08:00/09:00	X			XX		XXX
09:00/10:00				X		X
10:00/11:00						
11:00/12:00					X	X
12:00/13:00			X		X	XX
13:00/14:00						
14:00/15:00		XX				XX
15:00/16:00		X				X
16:00/17:00		X				X
17:00/18:00		X				X
18:00/19:00				X		X
19:00/20:00				XX		XX
20:00/21:00				X		X
21:00/22:00						
22:00/23:00						
23:00/00:00	X					X

4. Analysis of PMW measurements and H SAF and GPM precipitation products

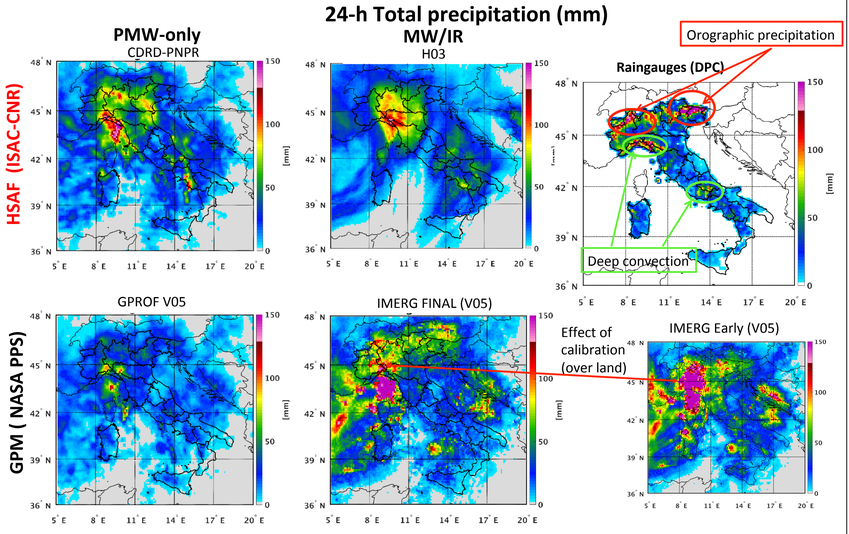
29 October 2018 event was monitored by 25 GPM constellation MW radiometer overpasses



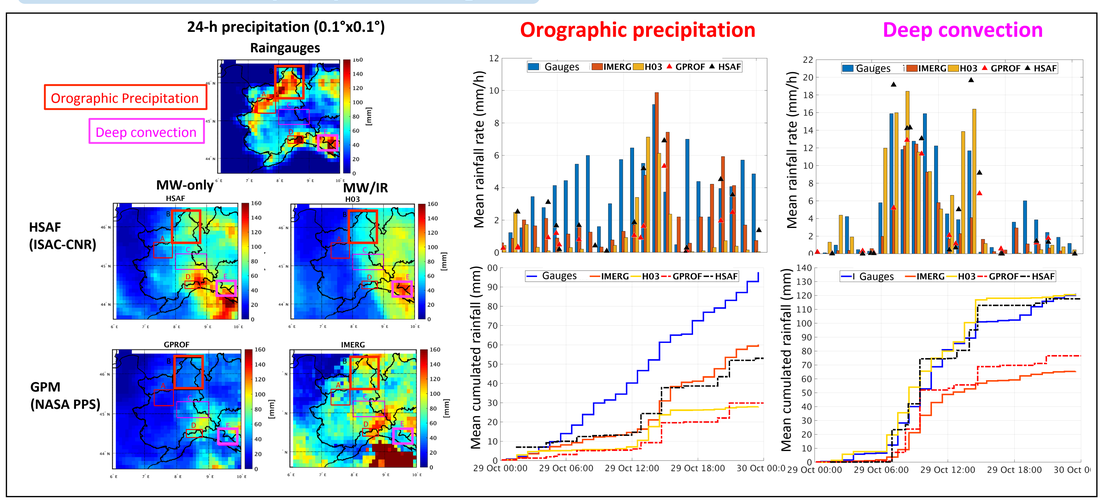
Precipitation rate evolution from GPM constellation MW radiometers



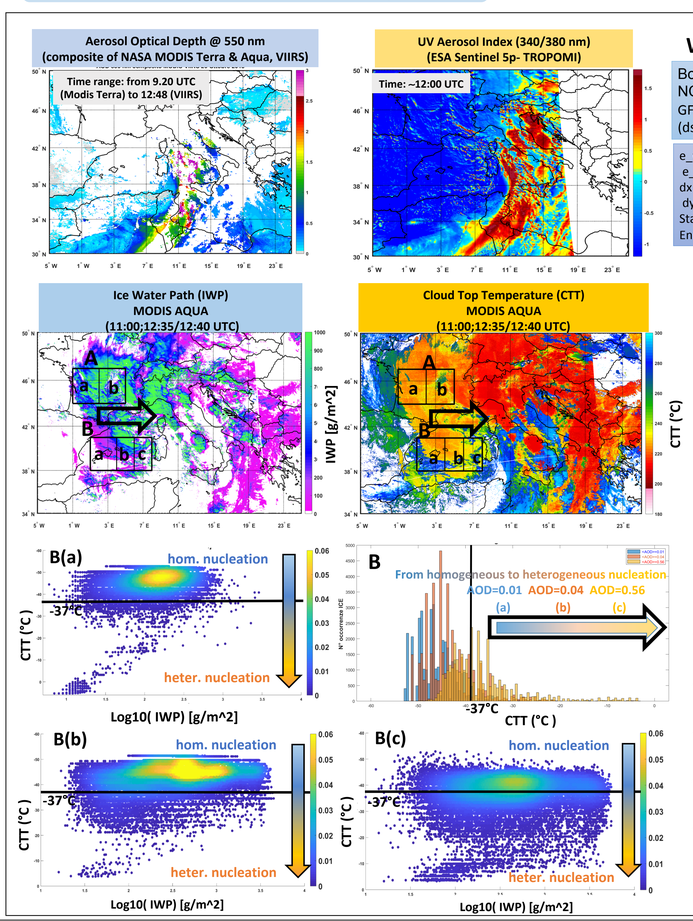
Precipitation Products	PMW	MW/IR
EUMETSAT H SAF (ISAC-CNR)	CDRD (SSMIS AMSR2) PNPR (MHS, ATMS, GMI)	H03 (NRT, 5 km 15 min)
GPM (NASA PPS)	GPROF V05	IMERG Final V05 (0.1°x0.1° 30 min)



5. QPE for different precipitation regimes



6. Desert Dust and Cloud Properties



WRF-CHEM Simulation

Boundary and initial conditions:
NCAR/ NCEP Final Analysis (FNL from GFS)
(ds083.2), with 1-degree resolution

e_we = 300,
e_sn = 300,
dx = 10000 m
dy = 10000 m
Start date/Time ; 2018/10/26 00UTC
End Date/Time: 2018/10/31 00UTC

Physics suite:

sf_sfclay = 5 => MYNN scheme
sf_surface = 3 => RUC (Rapid Update Cycle) Land Surface Model
bl_pbl = 5 => Mellor–Yamada–Nakanishi and Niino (MYNN) 2.5 level TKE
mp_physics =10 => Morrison et al. (2010) Two-moment microphysics scheme (cloud water, rain, graupel, snow, hail)
ra_lw_physics = 4 => Rapid Radiative Transfer (LW)
ra_sw_physics = 4 => Rapid Radiative Transfer Model (SW)
cu_physics = 3 => Grell–Freitas Ensemble Scheme

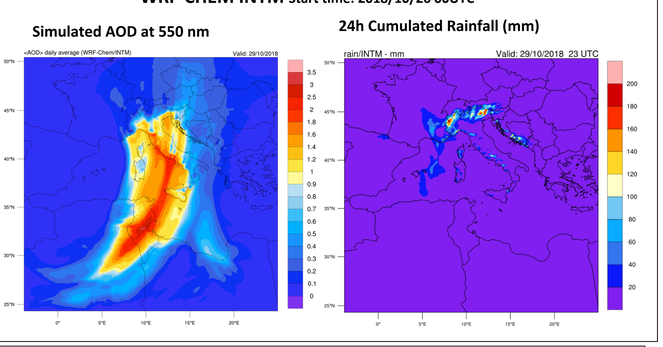
The **Aerosol-related model settings** have been implemented following the GOCART scheme (Chin et al., 2000)

It produces output for 8 sectional aerosol species:
4 dust bins (0–2.5, 2.5–5, 5–10, 10–20 μm);
4 sea salt bins (0.1–0.5, 0.5–1.5, 1.5–5, 5–10 μm).

Mineral dust and sea-salt emissions are surface wind speed dependent, while the other bulk species are prescribed from emission inventories .

Run	Chem opt	Dust Opt	Notes
INTM	300	3	Direct effects Gocart-afwa dust emission scheme
FULL	202	3	Direct+Indirect effects Gocart-afwa dust emission scheme

WRF-CHEM INTM Start time: 2018/10/26 00UTC



7. Conclusions

The MW measurements evidence the transition from a localized and very deep and persistent V-shape convective system over Liguria and Northern Tuscany to extremely intense and extended squall line from north to south that rapidly swept Italy moving eastward from the Tyrrhenian to the Adriatic Sea;

Satellite precipitation products evidence weaknesses in correctly estimating intense orographic precipitation, while H SAF products (optimized for the Mediterranean region) depict quite well precipitation associated to deep convective systems (better than global NASA GPM products).

NASA AQUA/TERRA MODIS and VIIRS observations and products evidence extremely intense Saharan dust outbreak (AOD at 550 nm exceeding 4) and the impact of dust on upper level clouds microphysical properties (lower CTT and higher IWP as AOD increases).

WRF-CHEM (without aerosol effects on clouds) is able to reproduce well the Saharan dust outbreak. A qualitative analysis shows that the precipitation in the Alpine region is well represented by the model, while the cloud structure and precipitation associated to deep convective systems are not well represented.

Future Work

- Analysis of the FULL WRF-CHEM simulation to evaluate impact of aerosol effect on cloud and precipitation microphysics
- Impact of initial conditions (change of initiation time)
- Analysis of upper level cloud features in connection with MW radiometer measurements (high frequency channels)

Acknowledgments

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